UNITED STATES
DEPARTMENT OF TRANSPORTATION

DSRC Communications Scalability Research Update

ITS-JPO Public Workshop
September 24, 2013

Mike Lukuc, NHTSA Research

V2V-Interoperability – Phase 2

- 2 year extension to the V2V-I Project: Oct 2012 – Aug 2014
- Collaborative effort between eight Automotive OEMs (Ford, General Motors, Honda, Hyundai-Kia, Mercedes-Benz, Nissan, Toyota, VW-Audi) and the USDOT
- Goal: Address remaining areas of interoperability research which are important to resolve in preparation for deployment of 5.9 GHz DSRC V2V crash avoidance safety applications

CAMP
Vehicle Safety Communications 3
Mercedes-Benz Research & Development North America, Inc.
GM
TOYOTA
HONDA
Honda R&D Americas
Ford
NISSAN
HYUNDAI·KIA MOTORS
Hyundai·Kia America Technical Center, Inc.
VOLKSWAGEN GROUP OF AMERICA
Intelligent Transportation Systems

NHTSA
www.nhtsa.gov

RITA U.S. Department of Transportation
Research and Innovative Technology Administration

This is US Government work and may be copied or distributed without permission

Interoperability Project – Phases 1 and 2

Interoperability – Phase 1 Major Tasks	Interoperability – Phase 2 Major Tasks
• V2V Safety Communications interoperability	• V2V Safety Communications Scalability
• V2V Safety Communications Scalability	• Misbehavior detection and reporting
• Security Management	• Technical support for NTIA/FCC spectrum study
• Data integrity and reliability	• DSRC Industry consensus standards development
• DSRC Industry consensus standards development	

This is US Government work and may be copied or distributed without permission

Communications Scalability for V2V Safety – Phase 2

- Goal
  - Finalize V2V safety communication protocol(s) that will support large-scale deployment level of vehicles while preserving the performance of V2V safety applications
- Activities
  - Algorithm refinement and, if necessary, development of alternate approaches
  - Field Testing
  - Calibration of communication simulation environments
  - Incorporate recommendations into relevant standards

This is US Government work and may be copied or distributed without permission

PHASE 1 SCALABILITY TESTING

100 and 200 vehicle tests

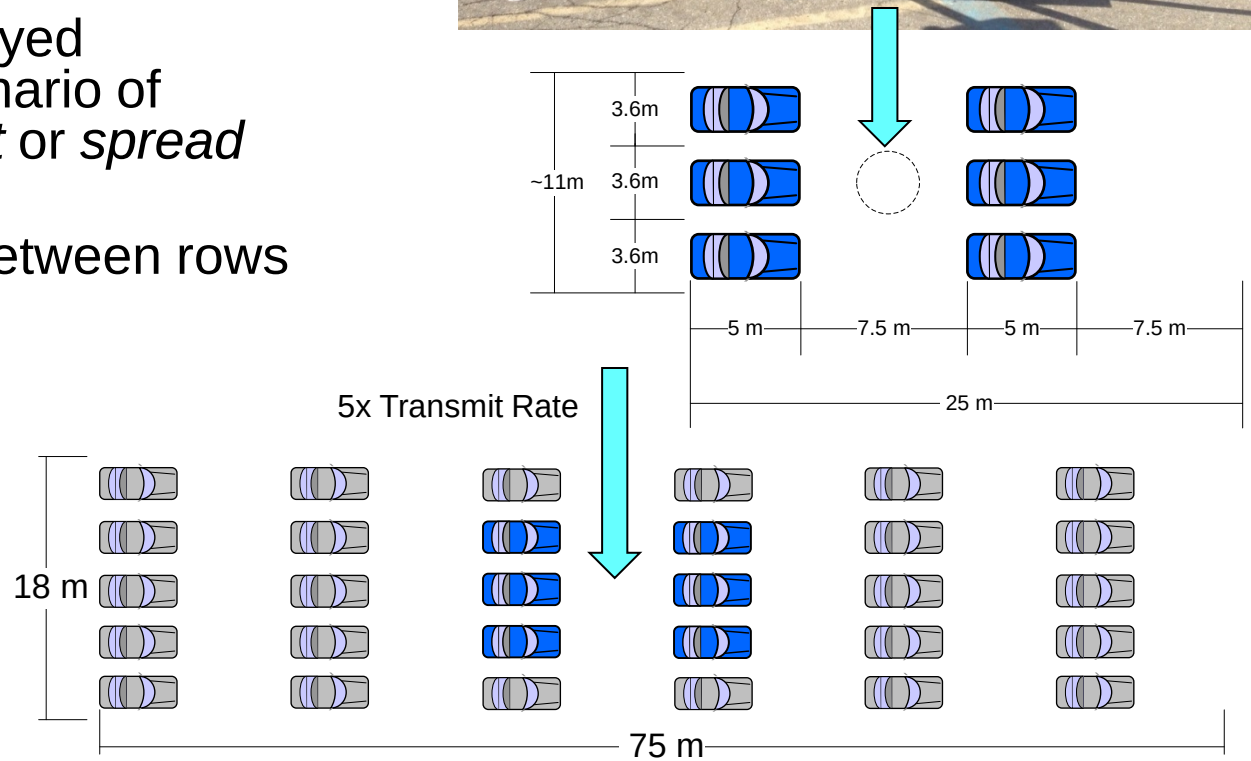
Field Testing

- Have tested 200 OBEs, will test 400
- Used static OBE carts as well as vehicles
- OBE Deployment Scenarios
  - Straight Road – Spread Out
  - Straight Road – Compact
- Used increased transmit rates to emulate additional vehicles (potentially up to 5x)
- Three types of tests
  - Non-application
  - Application
  - Hardware-in-the-Loop

This is US Government work and may be copied or distributed without permission

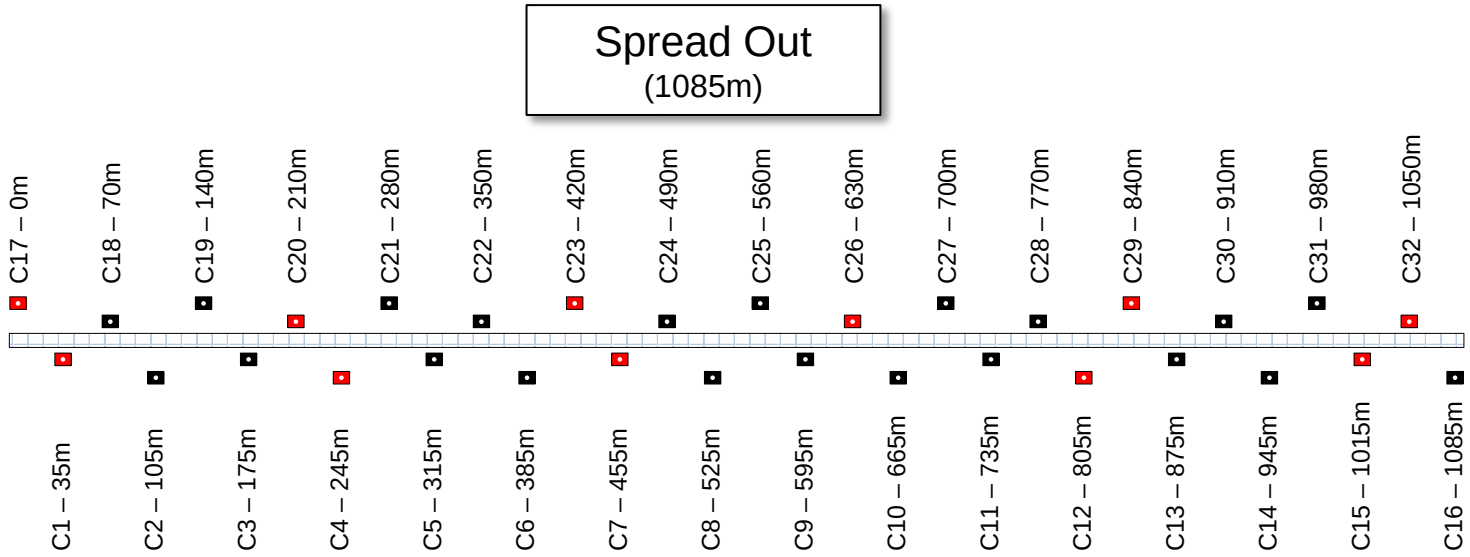
Static OBE Cart

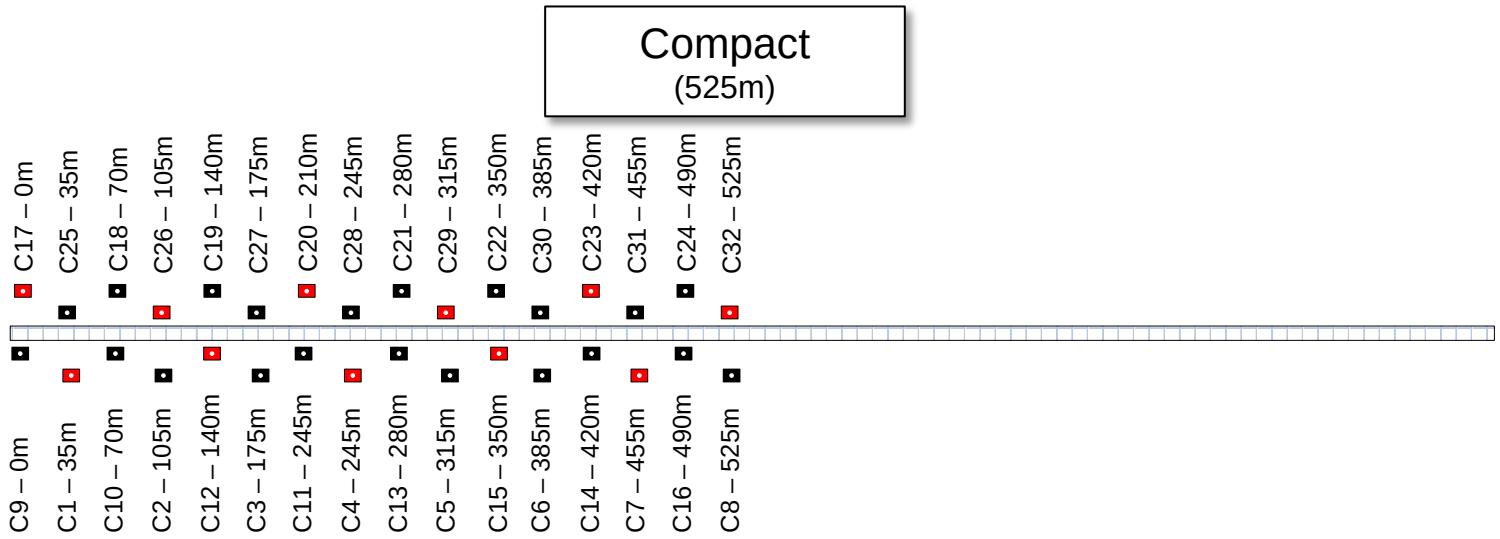
- Field testing relied primarily on OBEs mounted on static carts
- Each cart represents six vehicles
- At a 5x transmit rate each cart represents 30 vehicles
- Carts were deployed according to scenario of interest (*compact* or *spread out*)
- Vehicles drove between rows of carts



This is US Government work and may be copied or distributed without permission

OBE Deployment Scenarios (200 OBEs)

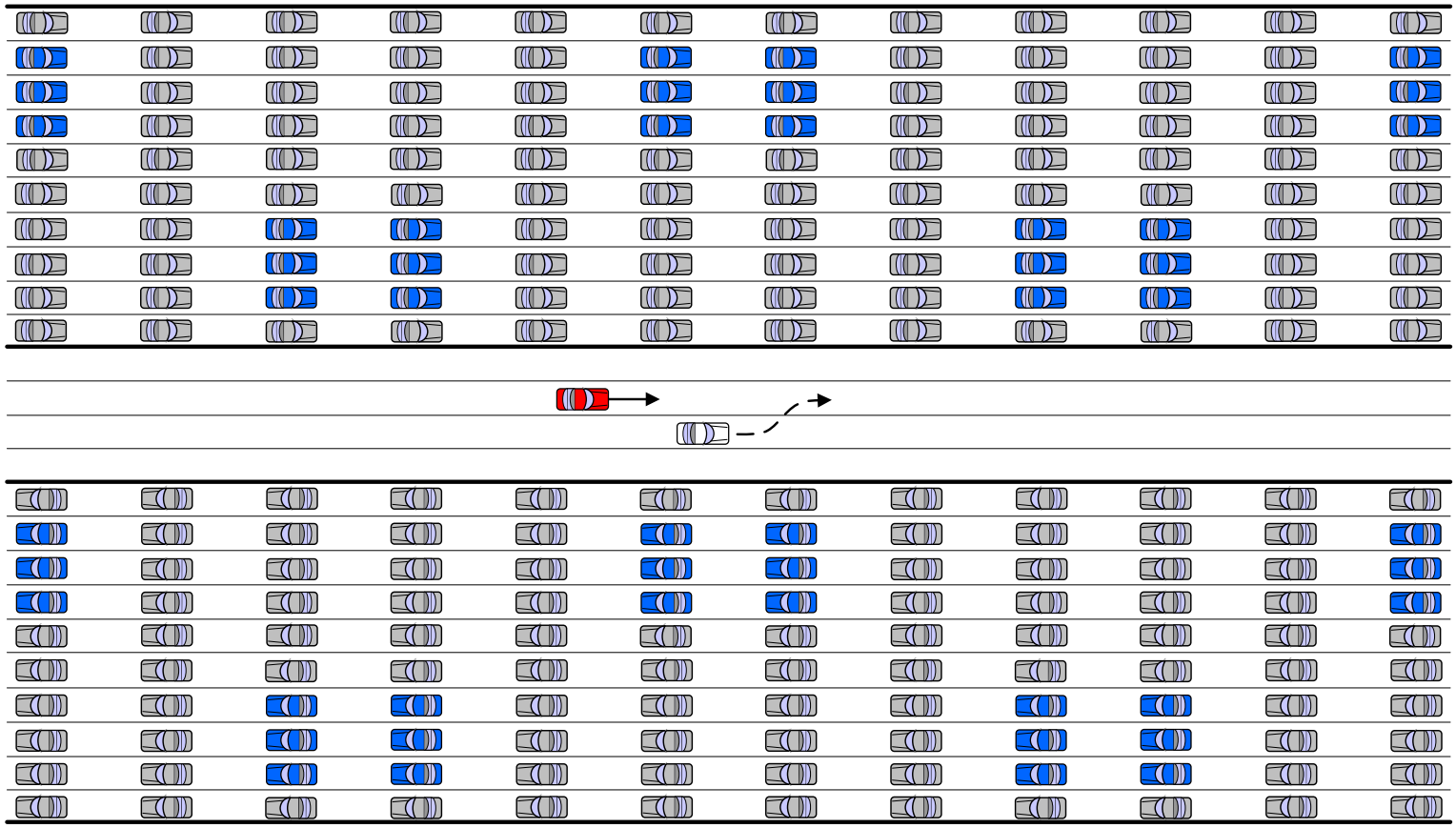




This is US Government work and may be copied or distributed without permission

High Density Vehicle Emulation for Compact Scenario

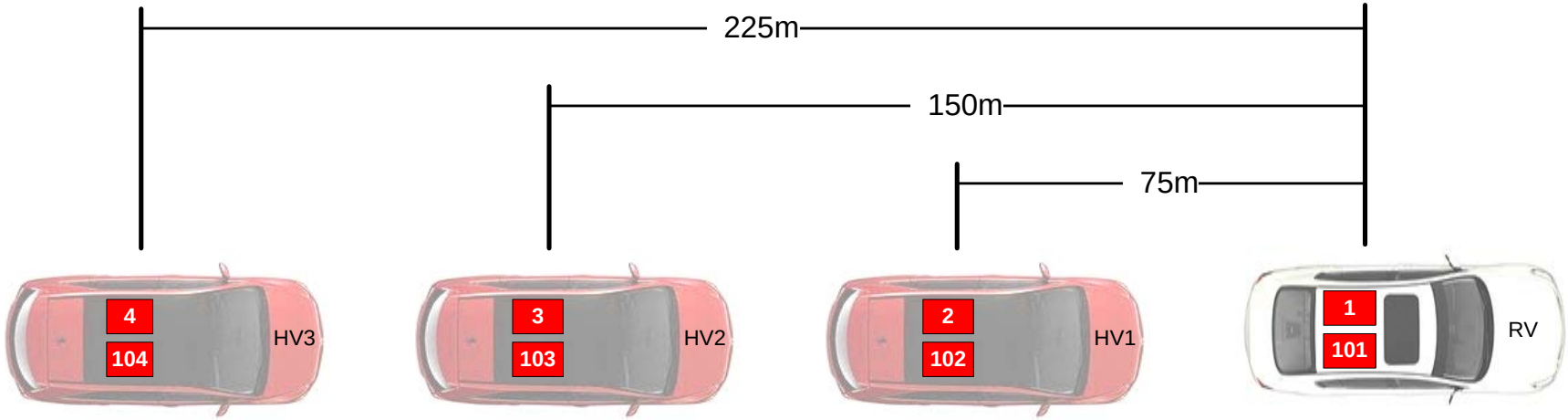
- Emulated 960 vehicles along a 525 m straight road
- This emulates 20 lanes of bumper-to-bumper traffic
- Application scenarios were performed between rows of carts



This is US Government work and may be copied or distributed without permission

Testing – Non Application: Vehicle Configuration

- For each OBE deployment configuration, analyze:
  - 10Hz, Algorithm X, and Algorithm Y behavior
  - Effects of varying power, data rate, AIFSN, etc.
- One remote vehicle (RV), three host vehicles (HVs)
- Each HV will follow at a fixed distance from the RV
- One of each supplier OBE placed on each vehicle



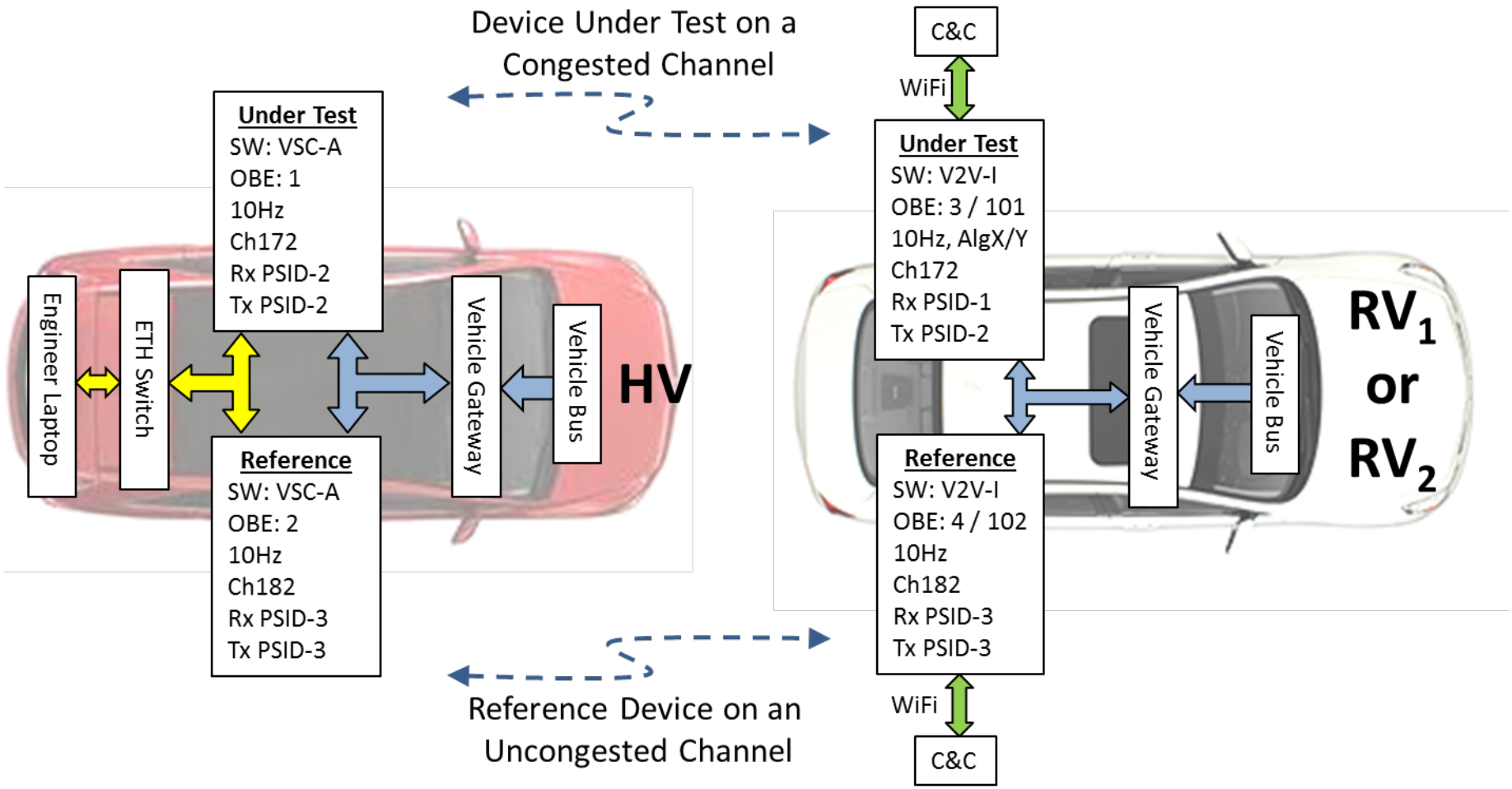
This is US Government work and may be copied or distributed without permission

Safety Application Testing in a Congested Environment

- Testing the performance of the V2V safety applications
- Testing the following transmit configurations
  - Baseline – 10Hz fixed transmit rate and power
  - Algorithm X – Adaptive transmission rate and power
  - Algorithm Y – Adaptive transmission rate
- Executing a set of safety application scenarios
- Comparing the actual warning range / timing to
  - Nominal warning range / timing
  - Reference system warning / timing

This is US Government work and may be copied or distributed without permission

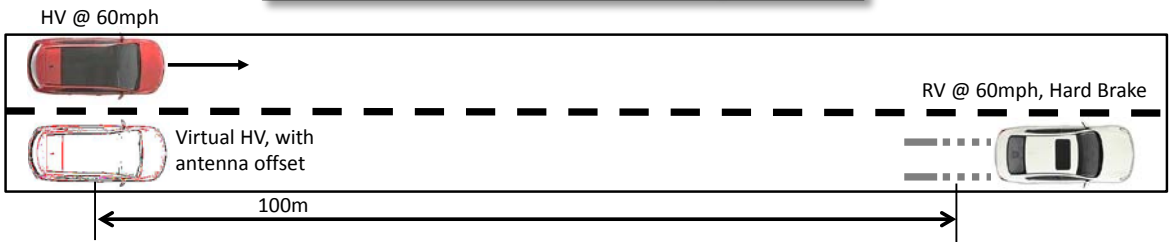
Testing – Application: Vehicle Configuration



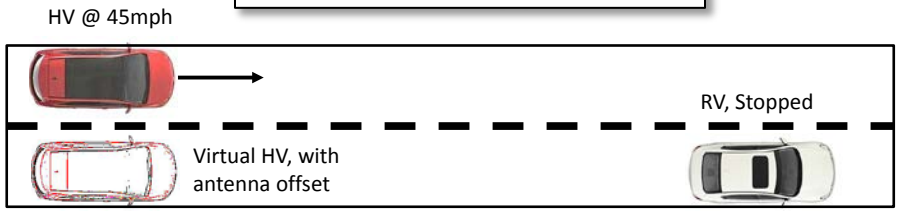
This is US Government work and may be copied or distributed without permission

Testing – Application: Scenarios

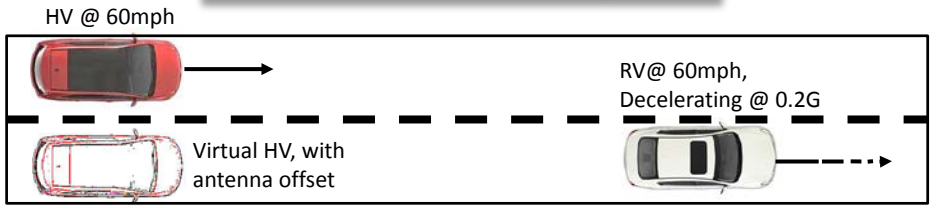
EEBL – Hard Braking RV



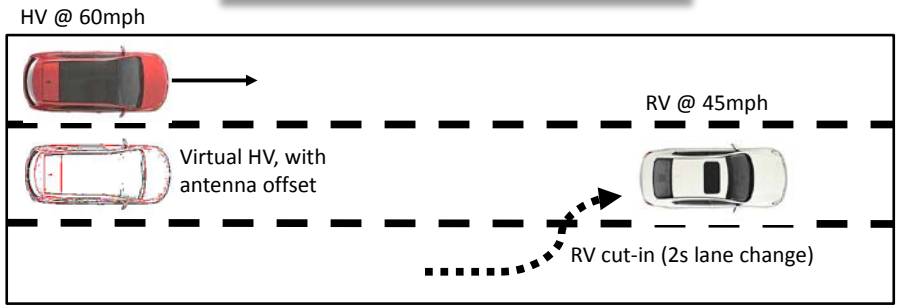
FCW – Stopped RV



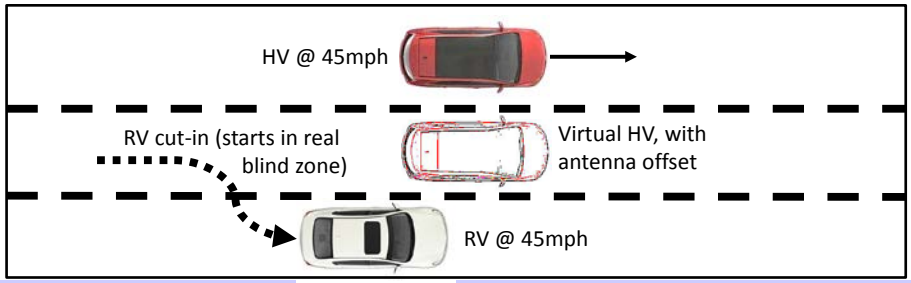
FCW – Decelerating RV



FCW – Cut-in RV



BSW – Cut-in RV



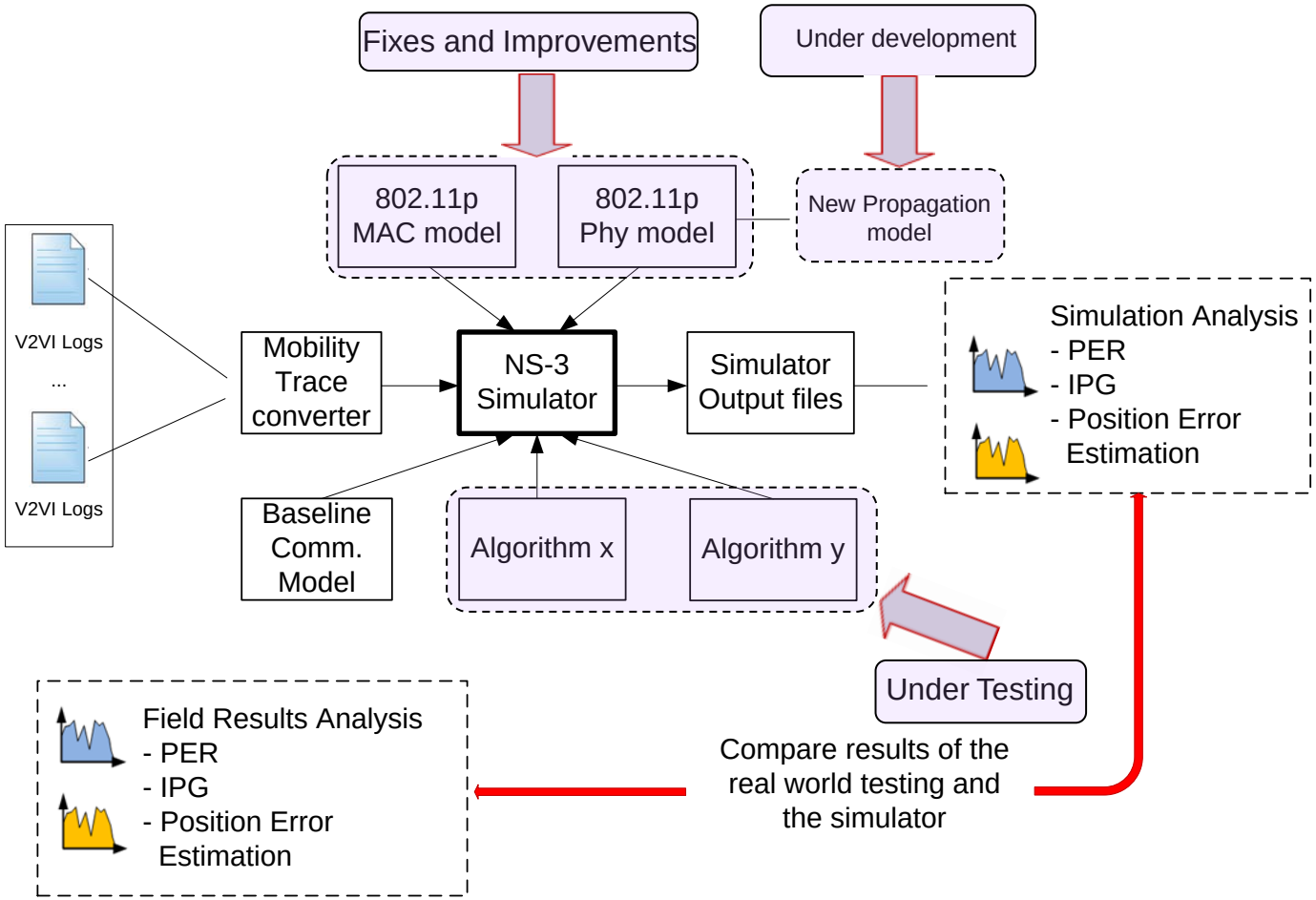
This is US Government work and may be copied or distributed without permission

Simulation Calibration

- Contracted two universities to work independently to calibrate simulation to real-world field test results
- Will move beyond field data and provide simulation results for full-deployment levels of vehicles
  - Algorithm refinements through simulation
  - Channel break-point determination
- Initial results will be verified through field tests
- Simulation feeds into the Hardware-in-the-Loop testing

This is US Government work and may be copied or distributed without permission

Simulation Calibration – Approach



This is US Government work and may be copied or distributed without permission

Testing and development Using Hardware-in-the-Loop (HIL) Testing

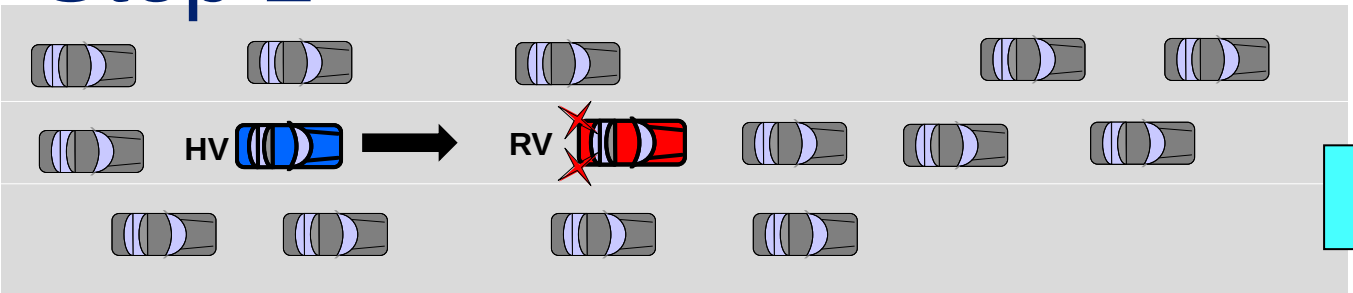
Step 1

- Crash scenario executed in the field
- No background congestion (1 RV and 1 HV only)
- High RV transmit rate (≥20Hz).
- **Create "high definition" log at HV**

Step 3

- **Playback log on the VSC-A OBE**
- **BSMs not received taken out**
- Evaluate application performance for given transmission control **algorithm**

Step 2



- Insert logged traces in simulator
- Introduce Heavy Congestion
- Transmit using **Baseline, Algorithm X, Algorithm Y**
- **Identify simulated BSMs actually received at HV**

This is US Government work and may be copied or distributed without permission

For questions, please contact:

Mike Lukuc
NHTSA Research
mike.lukuc@dot.gov